UM10714

SSL5301DB1213 flyback LED driver

Rev. 1 — 4 June 2014 **User manual**

Document information

Info	Content
Keywords	SSL5301DB1213, dimmable, LED driver, flyback converter, A19
Abstract	This user manual describes the operation of the SSL5301DB1213 230 V 12 W dimmable LED driver featuring the SSL5301 using a flyback topology. The SSL5301DB1213 demo board has a form factor that is compatible with the base of an A19 LED lamp fitting used in Solid State Lighting (SSL) applications.

Revision history

Rev	Date	Description
v.1	20140604	first issue

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1. Introduction

WARNING

Lethal voltage and fire ignition hazard

The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire.

This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

This user manual describes the operation of the SSL5301DB1213 230 V 12 W dimmable LED driver featuring the SSL5301. The SSL5301DB1213 demo board incorporates an A19 LED lamp compatible form factor. The flyback converter topology provides a simple and efficient solution for mains dimmable LED recessed light applications.

The SSL5301DB1213 demo board complies with EMI and safety regulations.

Figure 2 shows the SSL5301DB1213 demo board dimensions. The design and the components used ensure that the board fits into an A19 lamp base.

Figure 3 shows the top view and bottom view of the SSL5301DB1213 demo board.

2. Safety warning

The SSL5301DB1213 demo board input is connected to the 230 V mains. Avoid touching the board while it is connected to the mains voltage and when it is in operation. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Galvanic isolation from the mains phase using a fixed or variable transformer is always recommended. Figure 1 shows the symbols that identify these devices.

a. Isolated

b. Not isolated

Fig 1. Isolation symbols

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3. Specifications

Table 1 lists the specifications of the demo board.

Table 1. SSL5301DB1213 specifications

Symbol	Parameter	Value
V_{mains}	AC mains supply voltage	230 V ±15 %
I_{mains}	AC mains input current	< 65 mA
V_{LED}	output voltage	36 V (range: 30 V to 40 V)
I_{LED}	output current	250 mA
$I_{o(ripple)LED}$	LED output current ripple	±30 %
η	efficiency	85 %
PF	Power Factor	> 0.9 at V_{mains} = 230 V (AC)
THD	Total Harmonic Distortion	12 % at V_{mains} = 230 V (AC) and $V_{O(LED)}$ = 40 V (DC)
T_{oper}	operating temperature	−30 °C to +100 °C
f_{sw}	switching frequency	60 kHz

Figure 2 shows the dimensions of the demo board.

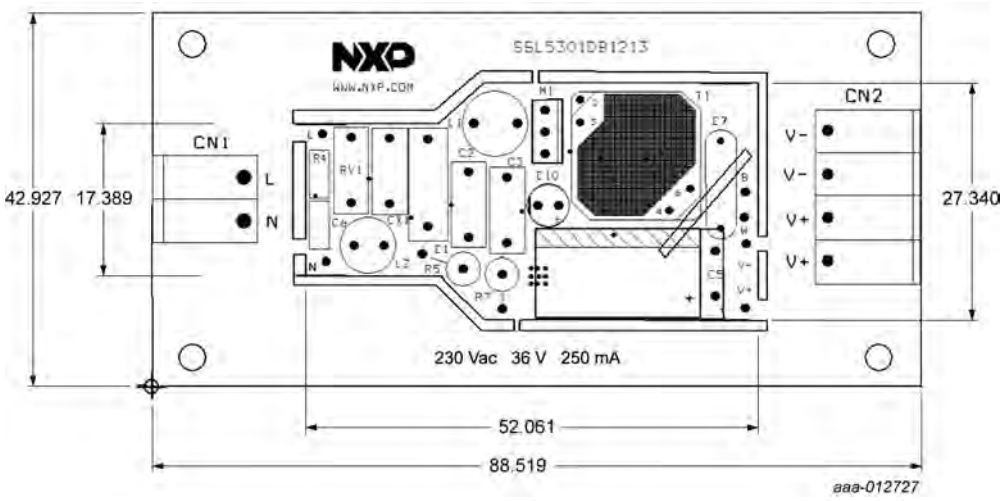

Fig 2. SSL5301DB1213 demo board dimensions

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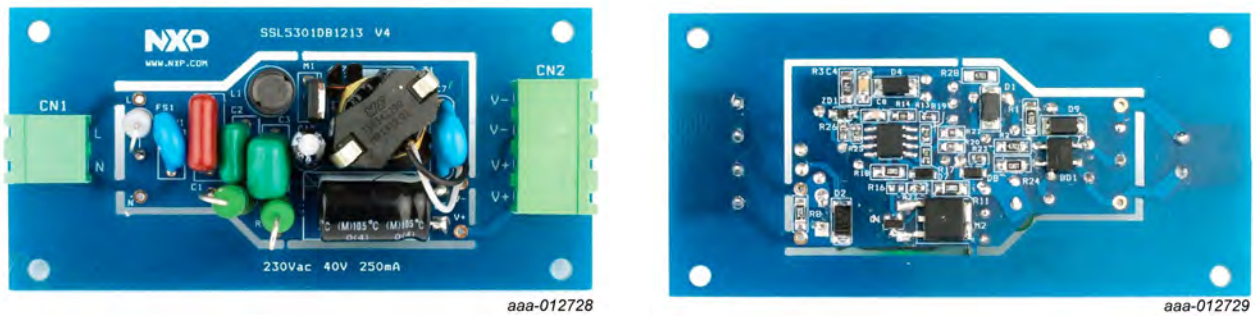
4. Board photographs



a. Top view

b. Bottom view

Fig 3. SSL5301DB1213 demo board

5. Board connections

The board is optimized for a 230 V/50 Hz mains supply. In addition to the mains voltage optimization, the board is designed to work with multiple LEDs or an LED module with a 40 V forward voltage. The mains connection of the SSL5301DB1213 demo board is different from other general evaluation/reference boards. Connect the mains to the crew connector CN1 (see Figure 4).

Remark: The maximum rated voltage of the board is 265 V (AC).

The anode of the LED load is connected to V+ of connector CN2 (see Figure 4). The cathode is connected to V− of connector CN2. Use an LED string with a forward voltage between 30 V and 40 V on this demo board. Under the expected conditions, the output current is 250 mA when no dimmer is used.

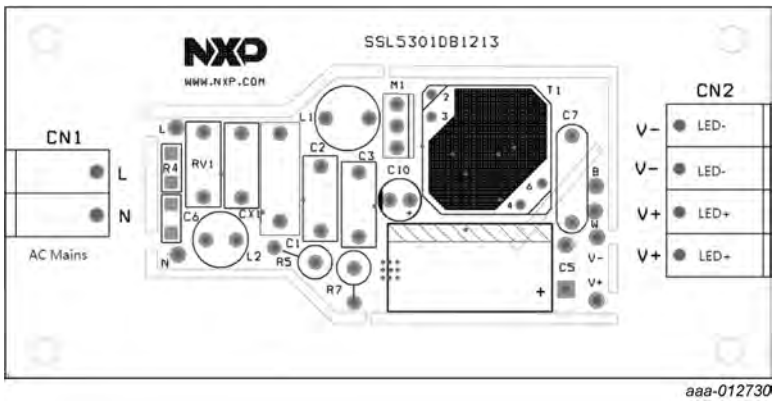


Fig 4. SSL5301DB1213 board connections

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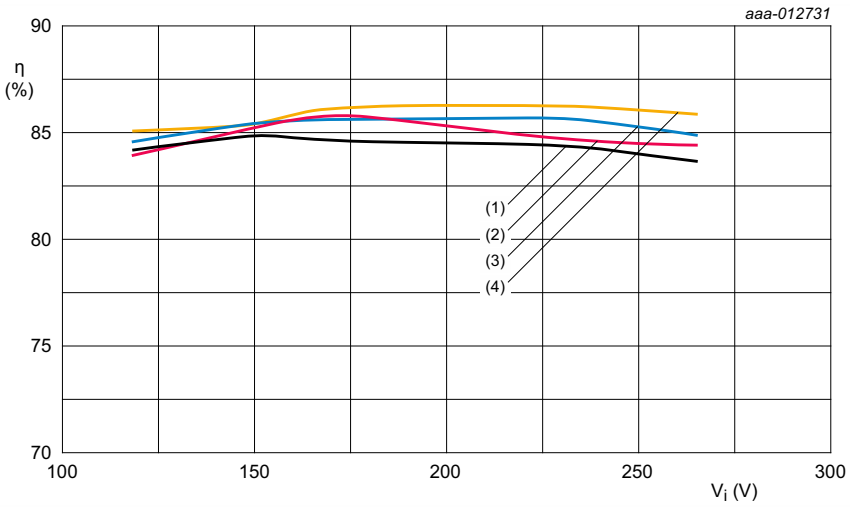
6. Performance

The performance was measured using an LED with a 40 V forward voltage at a 250 mA output load. Figure 5 to Figure 11 show the performance data.

6.1 Efficiency



(1) V_{LED} = 31 V
(2) V_{LED} = 34 V
(3) V_{LED} = 37 V
(4) V_{LED} = 40 V

Fig 5. Efficiency as a function of AC mains input voltage

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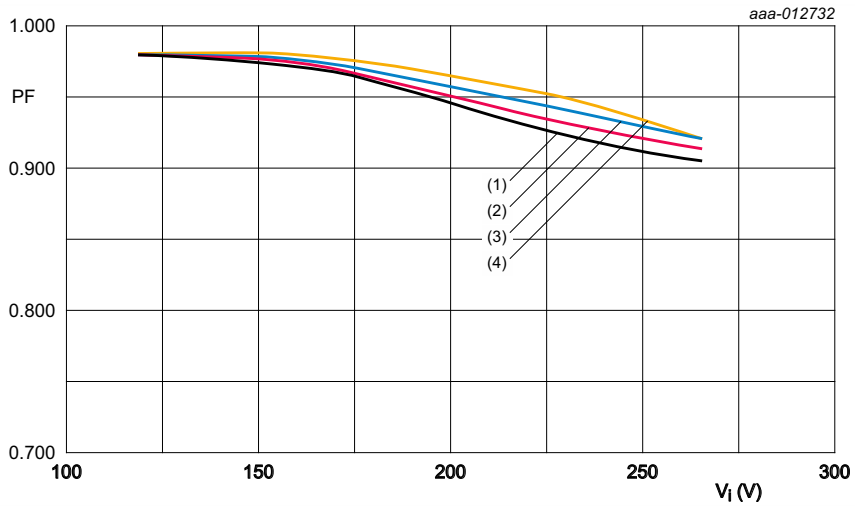
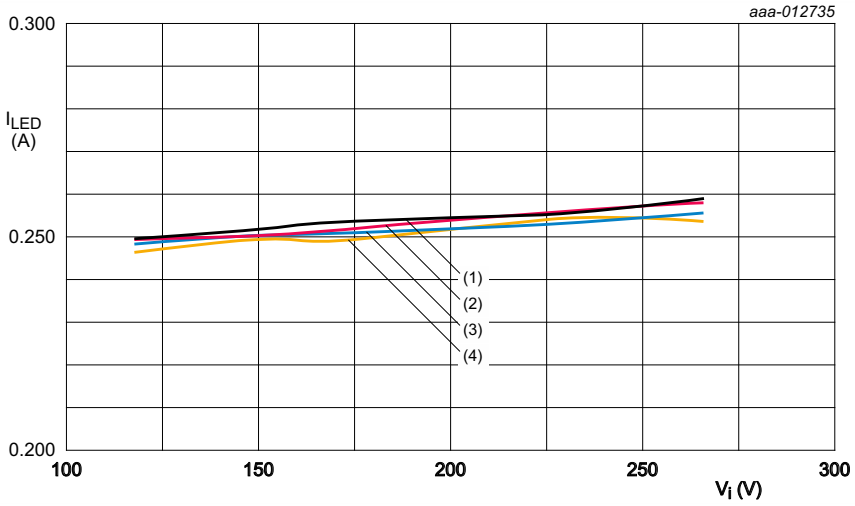
6.2 Power Factor (PF)



(1) V_{LED} = 31 V
(2) V_{LED} = 34 V
(3) V_{LED} = 37 V
(4) V_{LED} = 40 V

Fig 6. Power factor as a function of AC mains input voltage

6.3 Line regulation



(1) V_{LED} = 31 V
(2) V_{LED} = 34 V
(3) V_{LED} = 37 V
(4) V_{LED} = 40 V

Fig 7. Output current as a function of AC mains input voltage

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6.4 Load regulation

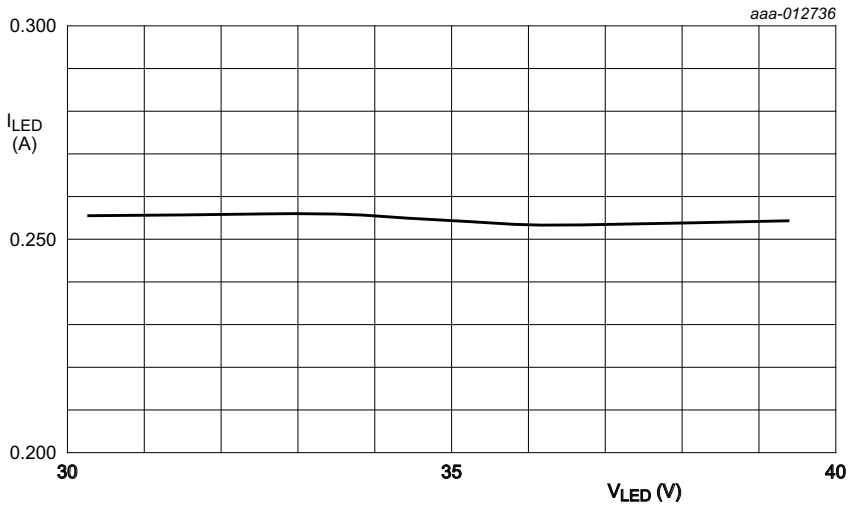

Fig 8. Output current as a function of output voltage at V_i = 230 V (AC)

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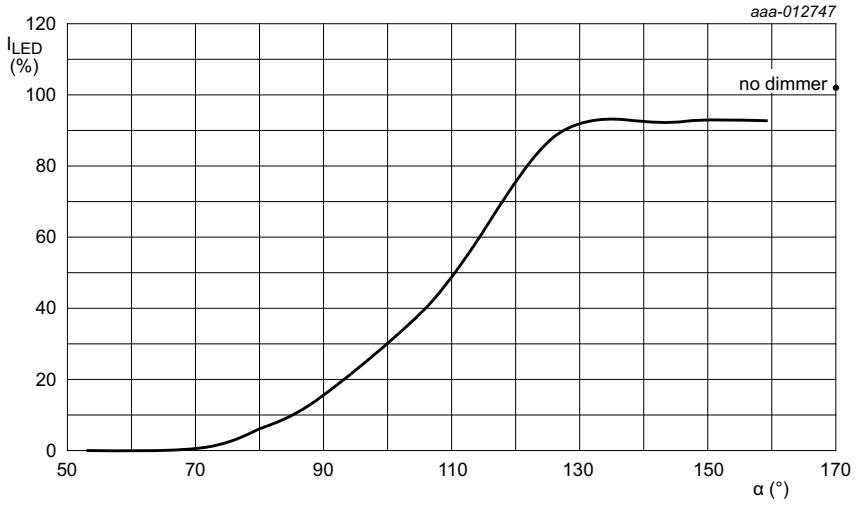
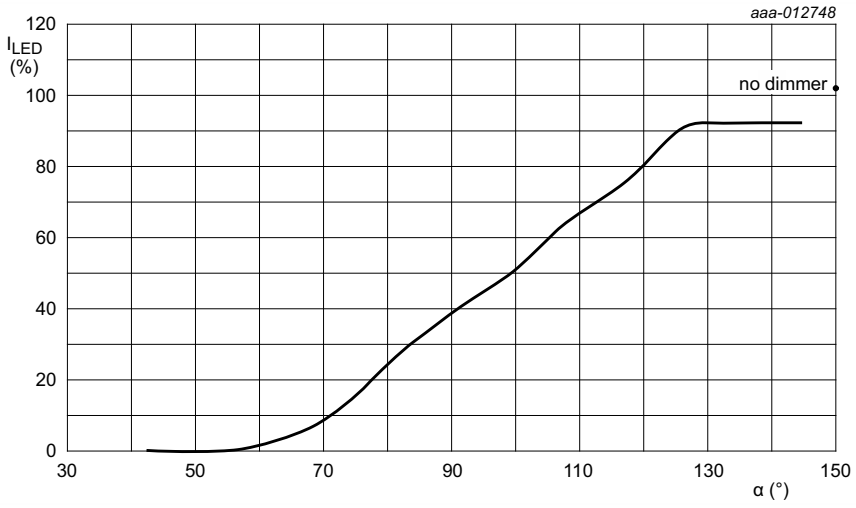
6.5 Dimming curves

Figure 9 shows the output current for a leading-edge dimmer and a trailing-edge dimmer. The output current without dimmer is also indicated. The maximum output current with dimmer equals 92 % of the output current when no dimmer is used. As a result, the input power of the SSL5301DB1213 demo board is the same with no dimmer as with dimmer and set at its maximum angle.



a. Leading-edge dimming



b. Trailing-edge dimming

Fig 9. Output current as a function of dimmer angle

Dimming compatibility includes smooth dimming without any flashing or flickering effects across the complete dimming range. The SSL5301DB1213 demo board has been tested with a wide selection of dimmers. It is compatible with most leading-edge and trailing-edge dimmers on the market.

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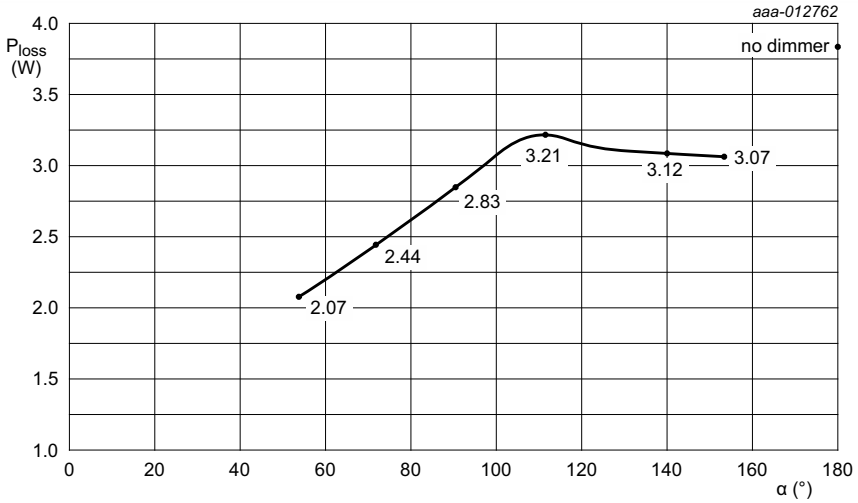
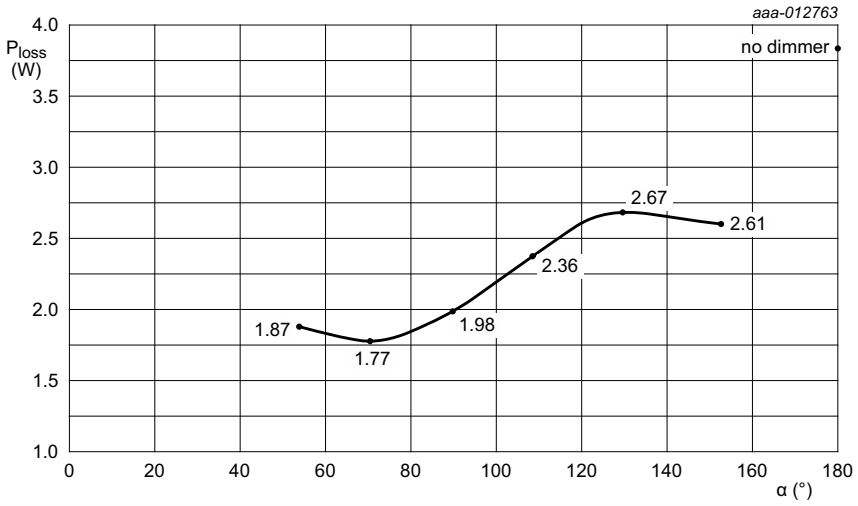
6.6 Power losses

Figure 10 shows the power losses when a leading-edge or a trailing-edge dimmer is used. The power losses when no dimmer is used are also indicated. Power losses are defined as the difference between input power and output power. They indicate the total power loss in the converter.



a. Leading-edge dimmer



b. Trailing-edge dimmer

Fig 10. Power losses as a function of dimmer angle

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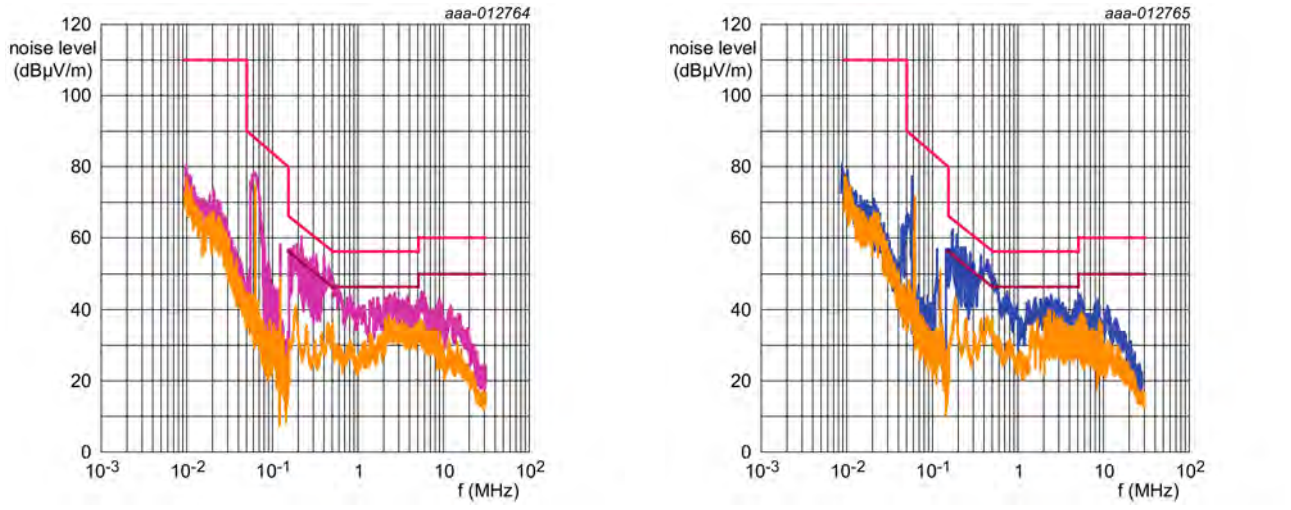
6.7 ElectroMagnetic Interference (EMI)

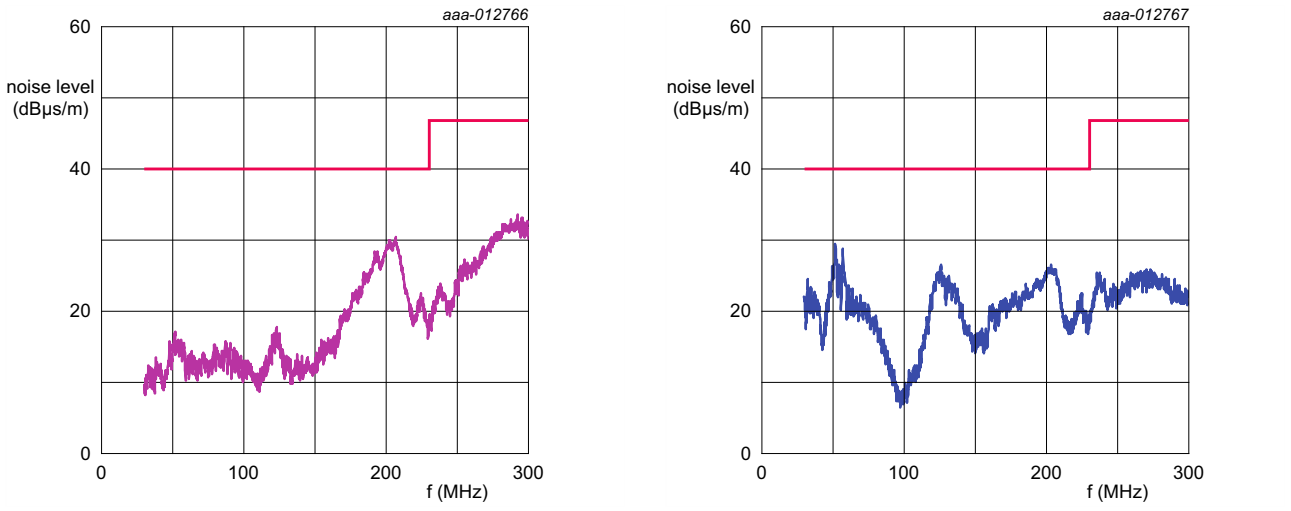
The ElectroMagnetic Interference (EMI) was measured according to the EN55015 standard. The board complies with the requirement (see Figure 11).



a. Live

b. Neutral

Fig 11. Conducted emission performance



a. Horizontal

b. Vertical

Fig 12. Radiated emission performance

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7. Protections

The IC incorporates the following protections:

- UnderVoltage LockOut (UVLO)
- OverCurrent Protection (OCP)
- Brownout protection
- Output Short Protection (OSP)
- Output open OverVoltage Protection (OVP)
- Internal OverTemperature Protection (OTP)
- Mains synchronization loss protection
- Leading-Edge Blanking (LEB)
- Bleeder dissipation protection

Output open OVP is a latched protection. Power-off cycling is required to exit the latched state. All other protections are not latched and lead to a safe restart of the converter. For more information about the protections, see the *SSL5301 data sheet* (Ref. 1).

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8. Schematic

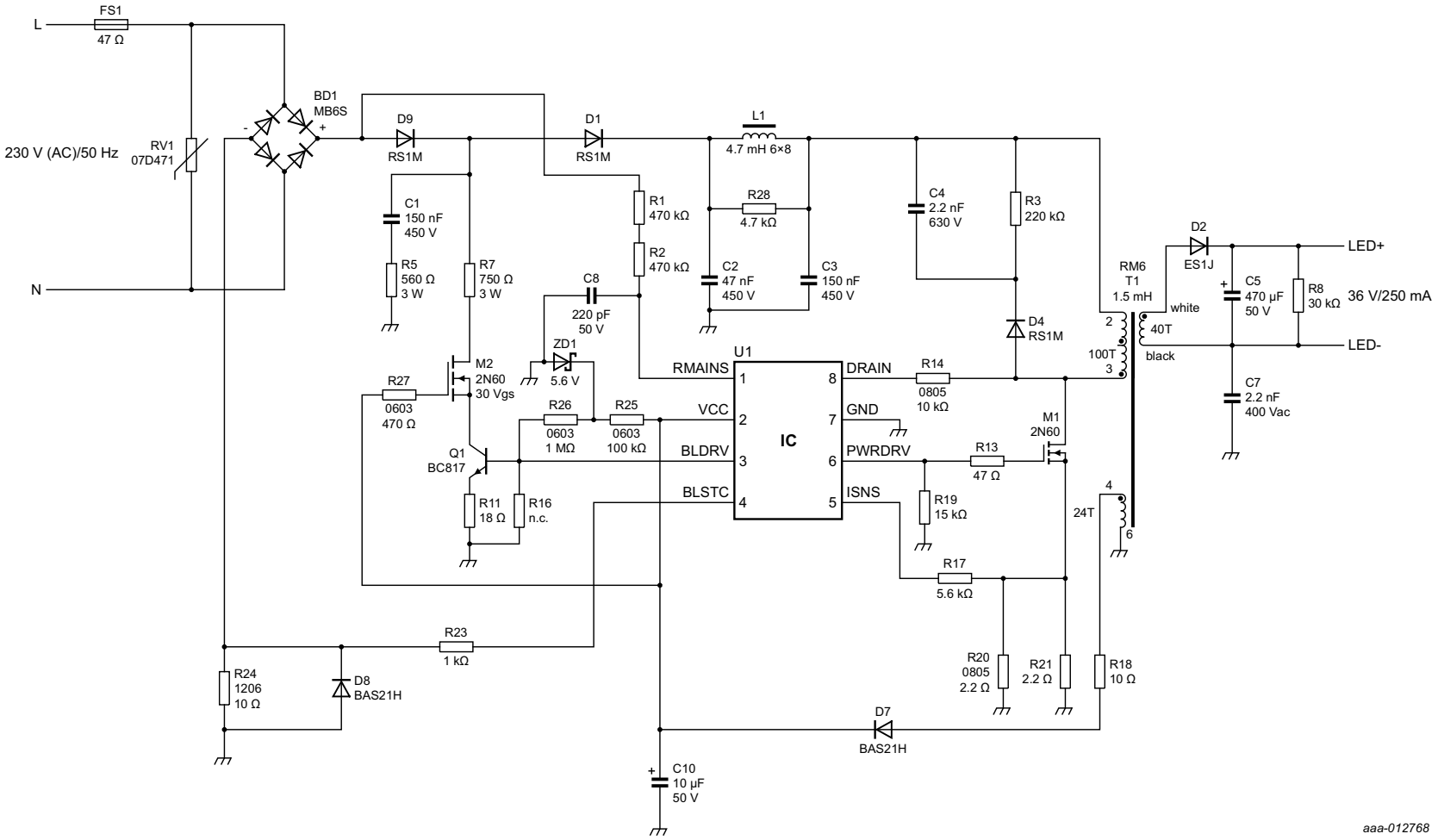

Fig 13. SSL5301DB1213 demo board schematic diagram

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9. Bill Of Materials (BOM)

Table 2. SSL5301DB1213 bill of materials

Reference	Description and values	Part number	Manufacturer
BD1	bridge rectifier; 0.5 A; 600 V; MB6S; MBS	-	-
C1	capacitor; film; 150 nF; 450 V; 10 %; P = 10 mm; DIP10	C222S154K40C000	Xiamen Fara
C2	capacitor; film; 47 nF; 450 V; 10 %; P = 7.5 mm; DIP7.5	CL21-450V-0.047K	ZhongShan AIDI Electronics
C3	capacitor; film; 150 nF; 450 V; P = 7.5 mm; 10 %; DIP7.5	CL21-450V-0.15K	ZhongShan AIDI Electronics
C4	capacitor; ceramic; 2.2 nF; 630 V; 10 %; 1206	GHM1530X7R222K630D500	Murata
C5	capacitor; electrolysis; 470 μF; 50 V; 20 %; 105 °C; 10 mm × 20 mm; LK; 8000 h; L-lead	-	Shanghai Yongming Electronics
C7	capacitor; Y; 2.2 nF; 400 V (AC); 10 %; P = 10 mm; DIP10	-	-
C8	capacitor; ceramic; 220 pF; 50 V; 0805; COG	GRM2165C2A221JA01	Murata
C10	capacitor; electrolysis; 10 μF; 50 V; 20 %;105 °C; 5 mm × 11 mm; ELE; 10000 h; axial lead	ELE-500ELL220ME11D	NCC
CN1	connector; L-pin; 2-pin; pitch = 5 mm; DIP2	691312710002	Würth Elektronik
CN2	connector; L-pin; 4-pin; pitch = 5 mm; DIP4	691312710004	Würth Elektronik
D1; D4; D9	diode; RS1M; 1 A; 700 V; SMA/DO-214AC	RS1M	Fairchild
D2	diode; 1 A; 600 V; ES1J; SMA/DO-214AC	ES1J	Diotec
D7; D8	diode; 0.2 A; 200 V; BAS21H; SOD123	BAS21H	NXP Semiconductors
FS1	resistor; fusible; 47 Ω; 2 W; 5 %; axial lead	FRN2W47RJ	TY-OHM
L1	drum inductor; power; 4.7 mH; 0.15 A; 6 × 8 mm; axial lead	-	Würth Elektronik
M1	N-MOSFET; 1.9 A; 600 V; V_{gs} = 30 V; ; IPAK/TO251;	FQU2N60C	Fairchild
M2	N-MOSFET; 1.9 A; 600 V; V_{gs} = 30 V; DPAK/TO252	FQD2N60C	Fairchild
Q1	transistor; NPN; 0.5 A; 45 V; SOT23	BC817	NXP Semiconductors
R1; R2	resistor; chip; 470 kΩ; 1 %; 1206	RC1206FR-07470KL	Yageo
R3	resistor; chip; 220 kΩ; 5 %; 1206	RC1206JR-13240KL	Yageo
R5	resistor; fusible; 560 Ω; 500 V; 3 W; 5 %; axial	FRN 3W 560Ω J	TY-OHM
R7	resistor; fusible; 750 Ω; 500 V; 3 W; 5 %; axial	FRN 3W 750Ω J	TY-OHM
R8	resistor; chip; 30 kΩ; 1 %; 1206	RC1206FR-0730KL	Yageo

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Table 2. SSL5301DB1213 bill of materials *...continued*

Reference	Description and values	Part number	Manufacturer
R10	resistor; chip; 390 kΩ; 1 %; 1206	-	Yageo
R11	resistor; chip; 18 Ω; 1 %; 1206	-	Yageo
R13	resistor; chip; 47 Ω; 1 %; 0603	RC0603FR-0747RL	Yageo
R14	resistor; chip; 10 kΩ; 1 %; 0805	RC0603FR-071KL	Yageo
R17	resistor; chip; 5.6 kΩ; 1 %; 0603	RC0603FR-075K6L	Yageo
R18	resistor; chip; 10 Ω; 1 %; 1206	-	Yageo
R19	resistor; chip; 15 kΩ; 1 %; 0603	RC0603FR-0715KL	Yageo
R20; R21	resistor; chip; 2.2 Ω; 1 %; 0805	RC0805FR-072K2L	Yageo
R23	resistor; chip; 820 Ω; 1 %; 0603	RC0603FR-07820RL	Yageo
R24	resistor; chip; 10 Ω; 1 %; 1206	RC1206FR-1310RL	Yageo
R25	resistor; chip; 100 kΩ; 1 %; 0603	RT0603FRE07100KL	Yageo
R26	resistor; chip; 1 MΩ; 1 %; 0603	RC0603FR-071ML	Yageo
R27	resistor; chip; 470 Ω; 1 %; 0603	RC0603FR-07470RL	Yageo
R28	resistor; chip; 4.7 kΩ; 1 %; 1206	-	Yageo
RV1	surge absorber; 471KD07; 300 V (AC); DIP5	471KD07	BrightKing
T1	transformer; RM6; 1.5 mH; RM-6-3	750342290	Würth Elektronik
U1	IC; SSL5301; SO-8	SSL5301	NXP Semiconductors
ZD1	Zener diode; 5.6 V; 0.55 W; 5 %; SOT323	BZX84J-B5V6	NXP Semiconductors

10. Tuning options

To increase dimmer compatibility, decrease the value of bleeder resistor R11 in order. If some smart dimmers cannot start up, try to decrease the resistor R26 value to get a higher start-up current of the bleeder.

To achieve a different output current, change the R20 and R21 resistor values. A lower resistance value results in a higher output current.

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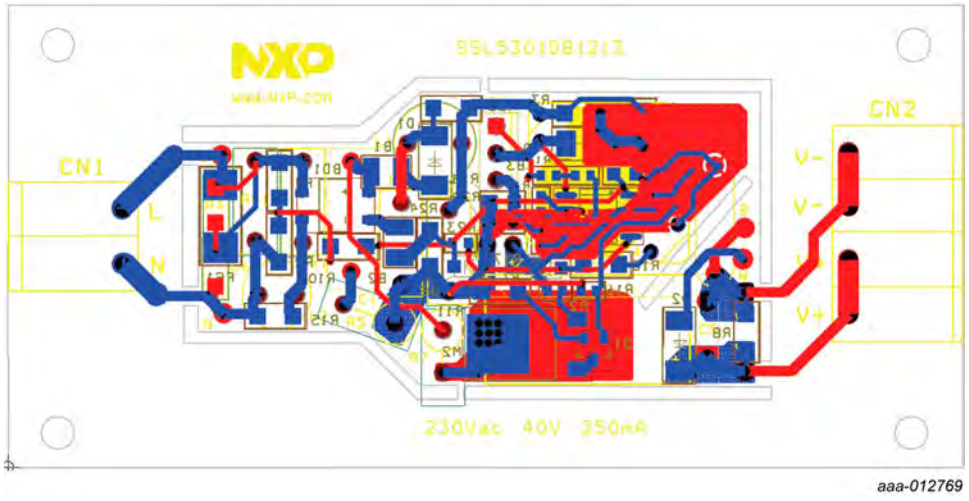
11. Board layout

Figure 14 shows the SSL5301DB1213 demo board layout of all four layers. Figure 15 show the outer layers of the board with their corresponding silk screen indicating component positions.



Red: Top

Blue: Bottom

Yellow: Silk screen top

Gray; Silk screen bottom

Fig 14. SSL5301DB1213 demo board with double layers, PCB only

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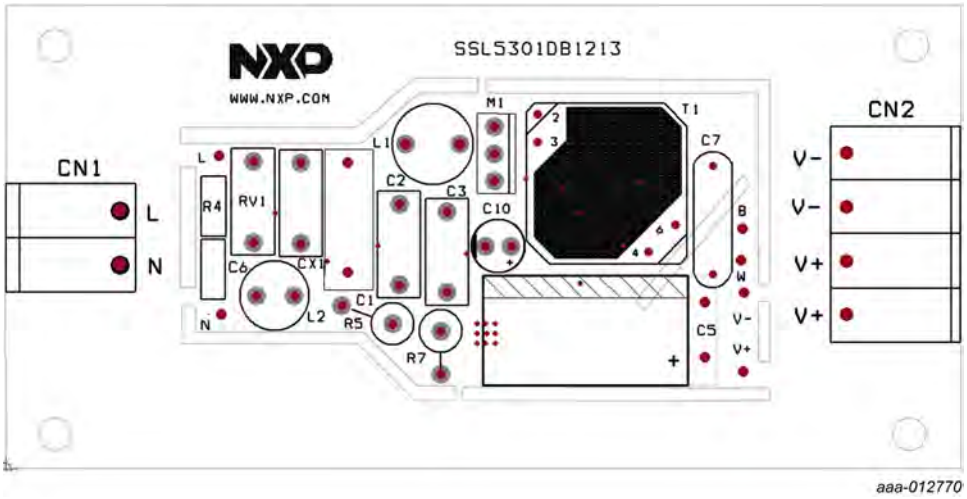
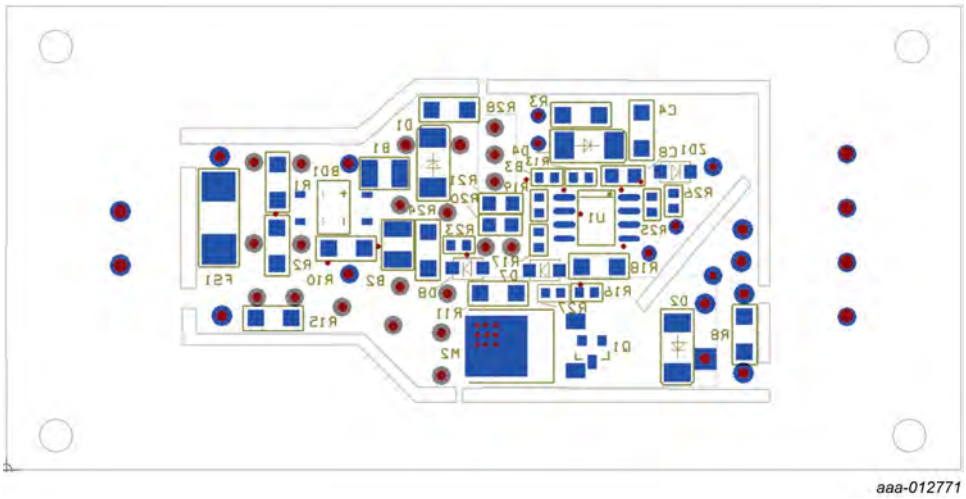


a. Top view



b. Bottom view

Fig 15. SSL5301DB1213 demo board assembly

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12. Transformer specification

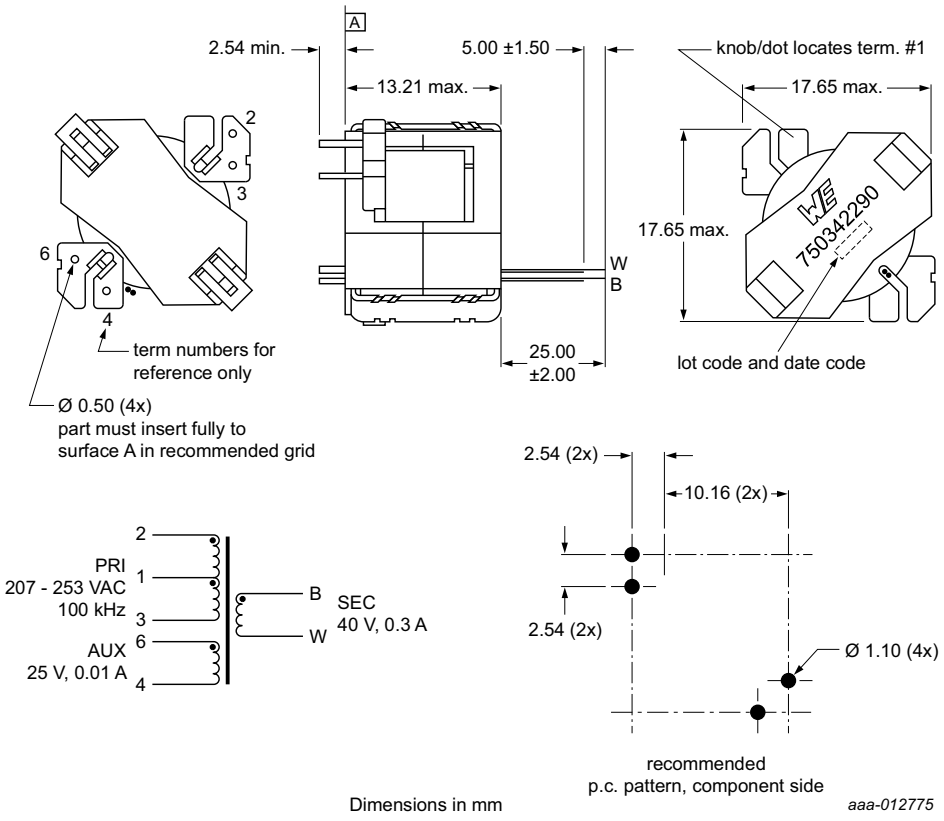

Fig 16. Specification of transformer T1

Table 3. Transformer T1 specifications

At 25 °C unless otherwise specified.

Parameter	Value	Test conditions
Electric specifications		
DC resistance 2-3	maximum 2.97 Ω	at 20 °C
DC resistance 6-4	maximum 0.811 Ω	at 20 °C
DC resistance B-W	maximum 0.674 Ω	at 20 °C
inductance 2-3	1.50 mH ±7 %	50 kHz; 0.1 V (AC); L_s
leakage inductance 2-3	maximum 20 μH	tie (4 + 6 + B + W); 100 kHz; 0.1 V (AC); L_s
dielectric 1-B	4000 V (AC); 1 minute	tie (3 + 4); 4000 V (AC); 1 s
dielectric B-core	1000 V (AC); 1 minute	tie (3 + 4 + B); 1000 V (AC); 1 s
dielectric 3-4	1800 V (AC); 1 s	1800 V (AC); 1 s
turns ratio	100T : 24T	(2-3) : (6-4)
turns ratio	100T : 40T	(2-3) : (B-W)
General specifications		
operating temperature	−40 °C to +125 °C	including temperature increase

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The T1 transformer has been designed to comply with the following requirements as defined by IEC60950-1:

- Reinforced insulation for a primary circuit at a 400 V (DC) working voltage.

13. Abbreviations

Table 4. Abbreviations

Acronym	Description
EMI	ElectroMagnetic Interference
LE	Leading-Edge
LED	Light Emitting Diode
PF	Power Factor
SSL	Solid-State Lighting
TE	Trailing-Edge

14. References

[1] **SSL5301 data sheet —** Mains dimmable controller for LED lighting

[2] **AN11533 application note —** SSL5301 driver for mains dimmable LED applications

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